DEPARTMENT OF
ECOLOGY
State of Washington

Quality Assurance Project Plan

Dungeness Bay and Lower Dungeness River Watershed Fecal Coliform Bacteria Total Maximum Daily Load Effectiveness Monitoring

February 2009

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Water Quality Assessment Listings Addressed in this Study:

Waterbody Name	Fecal Coliform Impairment Listings	LLID Number	Waterbody ID
Dungeness Bay	40377, 40379, 40380, 40382, 40383, 40384, 40385	1224199478564	--
Dungeness River	9935	1231331481508	WA-18-1010
Matriotti Creek	6969, 9913, 9914, 9916, 9918, 9920, 46401	1231400481357	WA-18-1012
Matriotti Ditch	45149	1231400481357	--
Meadowbrook Creek	9923, 9924, 9925, 45718, 46387, 46416	1231219481515	--
Meadowbrook Slough	9929	1231218481515	--
Unnamed Ditch (Tributary to Meadowbrook Creek)	46566	1231189481333	--
Cassalery Creek	6973, 21444	1230947481351	WA-18-1300
Cooper Creek	45823	1230998481381	--
Anderson Road Irrigation Ditch	45725	1231229481410	--
Lotzgesell Creek	45707	1231479481364	--
Bear Creek	45201	1231806481038	--
Cline Ditch	45824	1231593481376	--
Mudd Creek	45709	1231680481126	--
North Ditch	46547	not available	--
South Ditch	46655	not available	--

Additional Waterbodies Addressed in this Study:

- Meadowbrook Creek Remnant Channel LLID: 1231259481533
- Hurd Creek LLID: 1231422481243
- Golden Sands Slough LLID: 1231052481421

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TMDL – Total Maximum Daily Load
WQP - Water Quality Program
SWRO - Southwest Regional Office
SCS - Statewide Coordination Section
EAP - Environmental Assessment Program
WOS - Western Operations Section
EIM - Environmental Information Management system

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Abstract

The Washington State Department of Ecology (Ecology) is required under Section 303(d) of the federal Clean Water Act to (1) develop and implement Total Maximum Daily Loads (TMDLs; water cleanup plans) for impaired waters and (2) evaluate the effectiveness of the water cleanup plans in achieving the needed improvement in water quality.

Dungeness Bay, the Dungeness River, and several tributaries in the Dungeness River watershed are on the 303(d) list of impaired waterbodies due to violations of one or more Washington State water quality criteria. The U.S. Environmental Protection Agency (EPA) requires states to develop and implement TMDLs for listed parameters and to periodically monitor progress toward compliance with TMDL targets or water quality standards.

The main purpose of the study outlined in this Quality Assurance Project Plan is to evaluate the effectiveness and progress of TMDL implementation efforts. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives.

The study will assess the status of fecal coliform concentrations. The current status will be compared with fecal coliform target concentrations set in Dungeness Bay and all tributaries included in the initial TMDL studies.

Another purpose of the study is to evaluate waters in the vicinity that have shown signs of impairment due to other pollutants. Ecology's 2008 Water Quality Assessment lists three streams in the study area as impaired due to low dissolved oxygen concentration.

What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act Requirements

The Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, each state is required to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses for protection, such as cold water biota and drinking water supply, as well as criteria, usually numeric criteria, to achieve those uses.

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list. To develop the list, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data submitted by local, state, and federal governments; tribes; industries; and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before the data are used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides waterbodies into five categories:

Category 1 – Meets standards for the parameter for which it has been tested

Category 2 – Waters of concern

Category 3 – Waters with no data or insufficient data

Category 4 – Polluted waters that do not require a TMDL because:

- 4a. – Has an approved TMDL and it is being implemented.
- 4b. – Has a pollution control plan in place that should solve the problem.
- 4c. – Is impaired by a non-pollutant such as low water flow, dams, and culverts.

Category 5 – Polluted waters that require a TMDL – the 303(d) list.

TMDL Process Overview

The Clean Water Act requires that a TMDL be developed for each of the waterbodies on the 303(d) list. The TMDL identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Then Ecology works with the local community to develop an overall approach to control the pollution, called the Implementation Strategy, and a monitoring plan to assess effectiveness of the water quality improvement activities. Once the TMDL has been approved by the U.S. Environmental Protection Agency (EPA), development of a *Water Quality Implementation Plan* must begin within one year. This plan identifies specific tasks, responsible parties, and timelines for achieving clean water.

Elements Required in a TMDL

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources.

If the pollutant comes from a discrete (point) source such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If the pollutant comes from a set of diffuse (nonpoint) sources such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation*.

The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures is sometimes included as well. The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

Identification of the contaminant loading capacity for a waterbody is an important step in developing a TMDL. EPA defines the loading capacity as "the greatest amount of loading that a waterbody can receive without violating water quality standards" (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a waterbody into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load or wasteload allocation. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

TMDL = Loading Capacity = sum of all wasteload allocations + sum of all load allocations
+ margin of safety.

What is TMDL Effectiveness Monitoring?

TMDL effectiveness monitoring is a fundamental component of any TMDL implementation plan. It measures to what extent the waterbody has improved and whether it has been brought into compliance with the state water quality standards (Ecology, 2006). Effectiveness monitoring takes a holistic look at TMDL implementation, watershed management plan implementation, and other watershed-based cleanup efforts. Success may be measured against TMDL load allocations or targets correlated with baseline conditions, or desired future conditions. The benefits of TMDL effectiveness evaluation include:

- A measure of progress toward implementation of recommendations (for example, how much watershed restoration has been achieved, how much more effort is required).
- More efficient allocation of funding and optimization in planning and decision-making (for example, identifying recommendations or restoration activities that worked, which restoration activity achieved the most success for the money spent).
- Technical feedback to refine the initial TMDL model, best management practices, nonpoint source plans, and permits.

Water Quality Standards and Beneficial Uses

Fecal coliform bacteria

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In Washington State, the Department of Ecology's (Ecology) water quality standards use fecal coliform as an "indicator bacteria" for the state's freshwaters (for example, lakes and streams). Fecal coliform in water "indicates" the presence of waste from humans and other warm-blooded animals. All warm-blooded animals are a common source of serious waterborne illness for humans. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. Animals managed by humans are of particular risk because they are exposed to both human and animal derived pathogens. The fecal coliform criteria are set at levels that are shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

Once the concentration of fecal coliform in the water reaches the numeric criterion, the state does not allow human activities that would increase the concentration above that criterion. If the criterion is exceeded, the state requires that human activities are conducted in a manner that will bring bacterial concentrations back into compliance with the standards. The specific level of illness rates caused by animal versus human sources has not been quantified. If natural levels of bacteria (from wildlife) cause criteria to be exceeded, no allowance exists for human sources to measurably increase bacterial pollution.

Fresh waters

Primary Contact criteria are intended for waters where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing. *Primary Contact* use is designated to any waters where human exposure is likely to include exposure of the eyes, ears, nose, and throat. "Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200/colonies mL" [WAC 173-201A-200(2)(b)]. (Ecology, 2006)

Extraordinary Primary Contact criteria are intended for waters capable of providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas. To protect these uses, "Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100/colonies mL" [WAC 173-201A-200(2)(b)]. (Ecology, 2006).

Both *Extraordinary Primary Contact* and *Primary Contact* uses are present in freshwaters of the Dungeness watershed (see Figure 1). Compliance with the water quality standards are based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than

10 total samples) limit. These two measures are used in combination to ensure that bacterial pollution in a waterbody will be maintained at levels that minimize risk to human health. Some discretion exists for selecting sample averaging periods depending on site-specific conditions. Compliance may be evaluated using monthly (if five or more samples exist), seasonal (determined by rainfall quantity), and annual datasets.

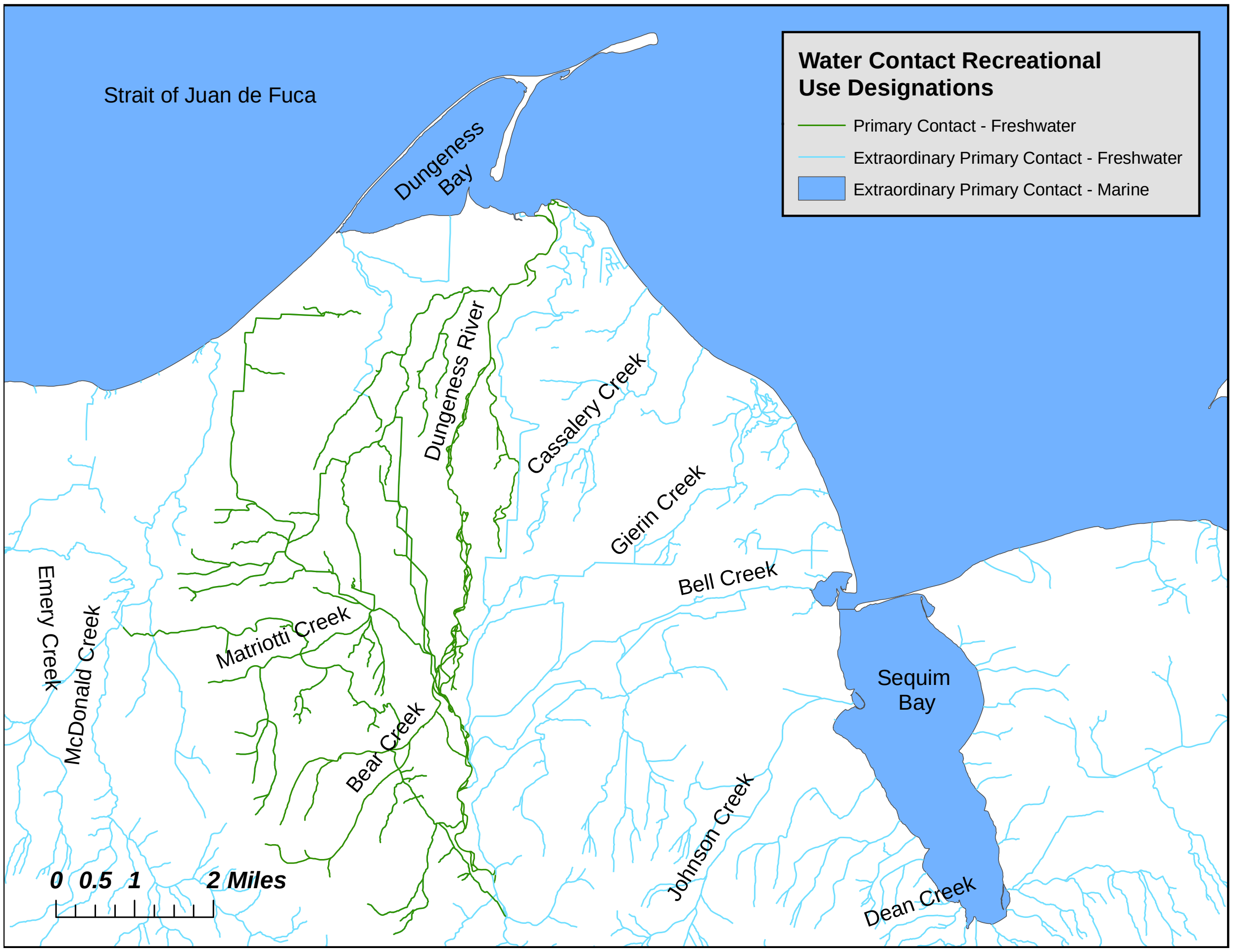

Figure 1. Recreational designated uses in the Dungeness watershed.

Washington State Surface Water Quality Standards (standards) (WAC 173-201A) have recently changed. In November 2006, Ecology adopted revised standards (Ecology, 2006). On February 11, 2008, the U.S. Environmental Protection Agency approved the revisions. Therefore the standards have changed since the 2002 and 2004 TMDL studies. Revisions to the standards did not effectively change the criteria for fecal coliform bacteria in the state. However, we will discuss the applicable historic and current standards for clarity. The recreational use standards for the Dungeness watershed are shown in Figure 1.

The historic water quality standards were based on the class designation of each waterbody. The class-based system grouped beneficial uses together into several classes. Due to the revision, each beneficial use is now applied to waterbodies separately. These general use designations together with a list of exceptions (Table 602, WAC 173-201A), determine the criteria applicable to each waterbody. Although the standards are now organized and presented differently, no changes to the recreational criteria were proposed in the revision process.

Table 602 of WAC 173-201A describes the following exception to the freshwater recreation criteria in the Dungeness watershed:

Primary Contact Recreation is the designated recreation use for, *"Dungeness River mainstem from mouth to Canyon Creek (river mile 10.8)".*

Due to general designation rules, all tributaries to this reach that are not named in Table 602 are designated *Primary Contact Recreation* waters. Matriotti Creek is a tributary to the reach of the Dungeness River described in this exception. However, due to a modification to the *Aquatic Life Use* designations in the 2006 Surface Water Standards, another exception in Table 602 designates Matriotti Creek as an *Extraordinary Primary Contact Recreation* water. These two exceptions are in conflict and are not consistent with the 1997 Surface Water Quality Standards *Recreational Use* designation of Matriotti Creek. Ecology has identified this error and has proposed a correction in the next revision of the Water Quality Standards. As such, Matriotti Creek maintains the *Primary Contact Recreation Use* designation as described in the standard prior to the recent revision.

Marine waters

In marine (salt) waters, bacteria criteria are set to protect shellfish consumption and people who work and play in and on the water. Fecal coliform are used as a compliance indicator because the presence of these bacteria in water indicates the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The concentration of fecal coliform bacteria in marine waters determines which waters are safe for contact recreation and shellfish harvesting.

To protect both *Shellfish Harvesting* and *Primary Contact Recreation* (swimming or water play): Ecology water quality standards require that "fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL" [WAC 173-201A-210(3)(b)]. (Ecology, 2006)

Compliance for fecal coliform criteria is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than 10 total samples) limit. These two measures are used in combination to ensure that bacterial pollution in a waterbody will be maintained at levels that minimize risk to human health. Some discretion exists for selecting sample averaging periods depending on site-specific conditions. Compliance may be evaluated using monthly (if five or more samples exist), seasonal (determined by rainfall quantity), and annual datasets.

In addition to the fecal coliform criteria set by Ecology, the Washington State Department of Health (DOH) has adopted fecal coliform criteria. These criteria are set by the National Shellfish Sanitation Program and determine when and where commercial shellfish harvesting is allowed. The fecal coliform concentration for shellfish harvesting are numerically the same for both

Ecology and DOH criteria. However, these criteria may differ in the number of samples required and the averaging period used to determine compliance. Both criteria are described for clarity.

The DOH Shellfish Protection Program, under the authority of RCW 43.70.185, monitors marine water quality for commercial shellfish harvesting. The DOH classifies shellfish growing areas based on their sanitary conditions under the direction of the U.S. Food and Drug Administration (FDA). The DOH classification methods are derived from the National Shellfish Sanitation Program (NSSP) Guide for the Control of Molluscan Shellfish (WDOH, 2007). The bacteriological quality of marine water samples collected from an approved growing area must satisfy both parts of the following standard.

- The concentration of fecal coliform bacteria, the indicator organisms, cannot exceed a geometric mean of 14 organisms per 100 milliliters (mL); and
- The estimated 90th percentile cannot exceed 43 organisms per 100 mL if sampling under the systematic random scheme. If sampling where point sources of pollution may impact the growing area, not more than 10% of the samples can exceed 43 organisms per 100 mL.

A minimum of 30 samples is used for these calculations. The use of 30 samples to calculate the growing area standards may include up to five years of data. When calculating the standards for Conditionally Approved growing areas, the DOH removes data collected under specific conditions such as storm events.

The ultimate performance measure of the Dungeness Bay Water Cleanup Plan is to achieve healthy water quality in the fresh and marine waters to re-open shellfish harvesting in the Dungeness Bay (Streeter and Hempleman, 2004). Thus, DOH fecal coliform data will be compared to the National Shellfish Sanitation Program (NSSP) criteria to determine the status and trend of water quality in Dungeness Bay. Fecal coliform data collected from tributaries to Dungeness Bay will be compared to Ecology's water quality criteria and targets set in the TMDL studies. Together these comparative evaluations will be used to determine the effectiveness of water cleanup efforts in the Dungeness watershed.

Dissolved Oxygen

Aquatic organisms are very sensitive to reductions in the level of dissolved oxygen in the water. The health of fish and other aquatic species depends on maintaining an adequate supply of oxygen dissolved in the water. Oxygen levels affect growth rates, swimming ability, susceptibility to disease, and the relative ability to endure other environmental stressors and pollutants. While direct mortality due to inadequate oxygen can occur, Washington State designed the criteria to maintain conditions that support healthy populations of fish and other aquatic life.

Oxygen levels can fluctuate over the day and night in response to changes in climatic conditions as well as the respiratory requirements of aquatic plants and algae. Since the health of aquatic species is tied predominantly to the pattern of daily minimum oxygen concentrations, the criteria are the lowest 1-day minimum oxygen concentrations that occur in a waterbody.

In the Washington State surface water quality standards, freshwater aquatic life use categories are described using key species (salmonids versus warm-water) and life-stage conditions (spawning versus rearing). Minimum concentrations of dissolved oxygen are used as criteria to protect different categories of aquatic communities [WAC 173-201A-200]. (Ecology, 2006)

For the Dungeness watershed, the following designated aquatic life use(s) and criterion are to be protected in freshwaters: “Core summer salmonids habitat” where the lowest 1-day minimum oxygen level must not fall below 9.5 mg/L more than once every 10 years on average.

The criterion described above is used to ensure that where a waterbody is naturally capable of providing full support for its designated aquatic life uses, that condition will be maintained. The standards recognize, however, that not all waters are naturally capable of staying above the fully protective dissolved oxygen criteria. When a waterbody is naturally lower in oxygen than the criteria, the state provides an additional allowance for further depression of oxygen conditions due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.2 mg/L decrease below that naturally lower (inferior) oxygen condition.

While the numeric criteria generally apply throughout a waterbody, they are not intended to apply to discretely anomalous areas such as in shallow stagnant eddy pools where natural features unrelated to human influences are the cause of not meeting the criteria. For this reason, the standards direct that measurements be taken from well-mixed portions of rivers and streams. For similar reasons, samples should not be taken from anomalously oxygen-rich areas. For example, in a slow moving stream, focusing sampling on surface areas within a uniquely turbulent area would provide data that are erroneous for comparing to the criteria.

Project Background

Study Area

Dungeness Bay is located in Clallam County near Sequim, Washington, on the northeast coast of the Olympic Peninsula. The outer edge of Dungeness Bay is defined by Dungeness Spit, extending in a narrow five-and-a-half-mile curve into the Straits of Juan de Fuca. Dungeness Bay is nearly divided by Graveyard Spit (which extends south from Dungeness Spit) and Cline Spit (which extends north from the mainland). A relatively narrow opening between these two spits allows tidal waters to flow between inner Dungeness Bay and outer Dungeness Bay (Streeter and Hempleman, 2004).

The Bay has traditionally been rich in littleneck clams. Native people have harvested shellfish here throughout tribal memory. In more recent times, the Bay has been a profitable source of commercial farmed oyster harvest and popular for recreational harvest. Commercial shellfish harvest is a source of income to the community and provides local jobs. Recreational harvest is popular with residents and tourists, and it contributes to the image of the Dungeness as a beautiful and pristine area (Streeter and Hempleman, 2004).

Land uses in the lower Dungeness valley include commercial, residential, and agricultural. Sequim has become increasingly urbanized in recent decades, and residential land use is becoming more predominant (Hempleman and Sargeant, 2002). The city of Sequim is on a sewer system while residential and commercial businesses in the rural area use on-site sewer treatment systems.

Failures of these on-site systems can contribute to the elevated fecal coliform levels in freshwater tributaries to the Bay (Sargeant, 2002). Citizen education, on-site inspections, and system repairs conducted by the Clallam County Health and Human Services continue to reduce these nonpoint sources. Further, the Clallam County Department of Health and Human Services, the Environmental Health Division (Clallam County), and the Jamestown S'Klallam Tribe (JSKT) decommissioned eight on-site systems from the mouth to river mile 1.0 (Hals, 2008).

The climate in this region of the Olympic Peninsula is drier because it lies in the rain shadow of the Olympic Mountains. Precipitation varies from 15 inches near Sequim to 80 inches in the headwaters of the Dungeness River. Due to the low rainfall, the lower Dungeness valley contains an extensive irrigation system to support agricultural crops. Like small streams, this network of irrigation ditches is another conduit for fecal coliform to enter Dungeness Bay and its tributaries. Prior to the TMDL, there were more than 97 miles of irrigation ditches, with approximately 11,000 acres irrigated (Sargeant, 2001). Agricultural best management practice implementation and technical assistance from Clallam Conservation District have reduced fecal coliform inputs to the irrigation system.

Recent projects conducted by the Clallam Conservation District and the Sequim-Dungeness Water Users Association have replaced many open irrigation ditches with buried pipelines, often capping the end of the pipelines to eliminate irrigation water discharges to the Bay and its tributaries. These projects reduce the amount of water diverted from the Dungeness River, help prevent pollutants from entering the irrigation system, and when totally enclosed, eliminate tailwater discharges at the end of the system.

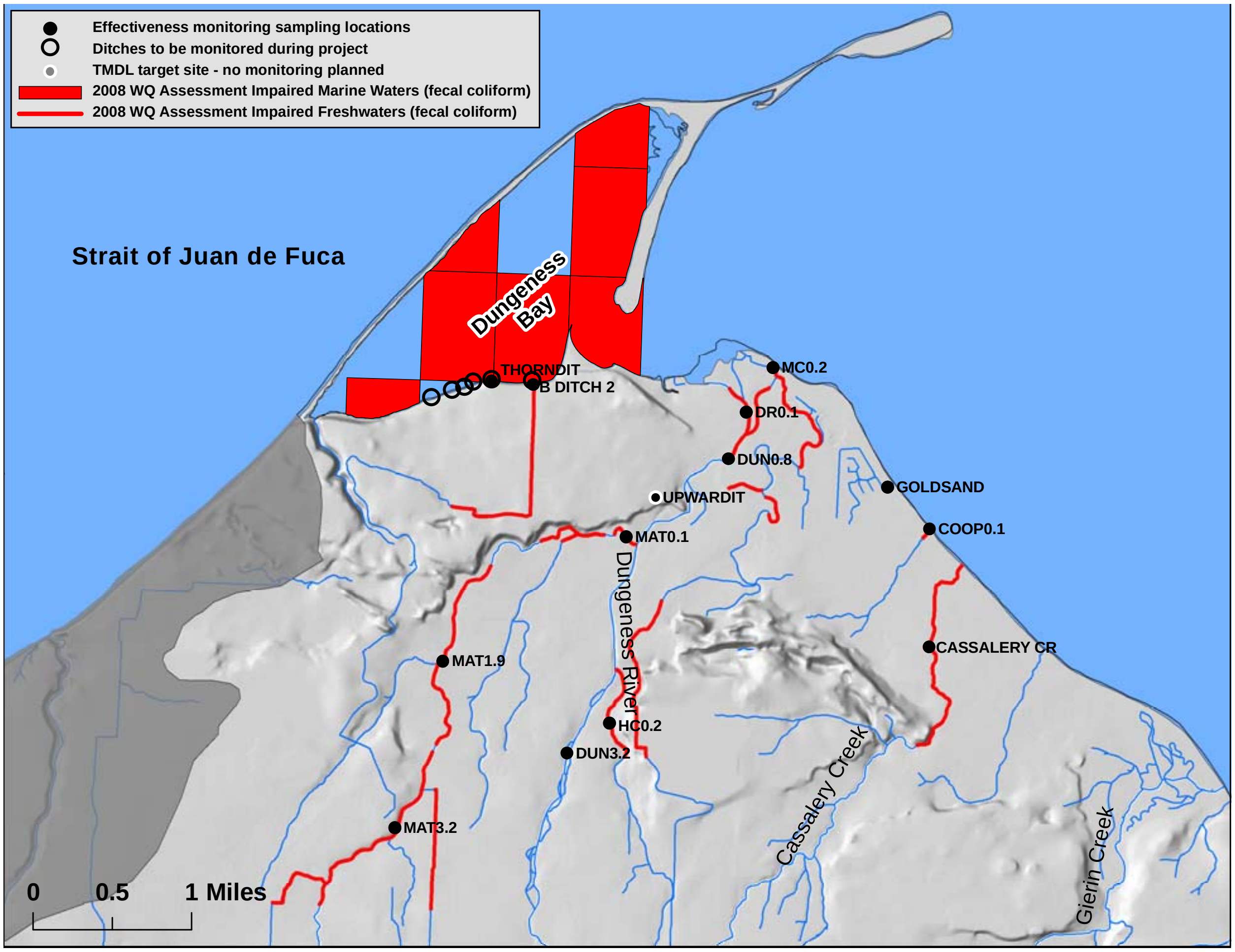

Figure 2. Effectiveness monitoring sampling sites.

Major tributaries to Dungeness Bay

The Dungeness River flows north into the outer Dungeness Bay just east of the opening between Graveyard and Cline Spits. The river is 32 miles long and drains 172,517 acres. The upper two-thirds of the watershed are within national forest and national park areas. The river contributes the highest volume of freshwater to the Bay.

Several other tributaries that enter the Dungeness River are also included in this study. At the time of the 1999-2000 TMDL study, an irrigation tailwater return entered the Dungeness River on the left bank (looking downstream) at river mile (RM) 1.0. This site is UPWARDIT. This irrigation return has been piped and capped, and no longer discharges to the Dungeness River except for rare occasions when the pipeline needs to be flushed (Holtrop, 2008). Matriotti Creek is 9.3 miles long and flows into the Dungeness River on the left bank at RM 1.9. Hurd Creek is approximately one mile long and flows into the Dungeness River on the right bank at RM 2.7.

Meadowbrook Creek flows north into the Bay 0.4 miles east of the Dungeness River mouth. Meadowbrook Slough is approximately 0.5 miles long and flows into Meadowbrook Creek just before the creek enters the bay.

Other TMDL target tributaries

Golden Sands Slough discharges into outer Dungeness Bay southeast of Meadowbrook Creek. The slough is a series of constructed channels in an estuarine wetland area. Water in the slough tends to be saline and stagnate (Sargeant, 2002).

Cooper Creek discharges into Dungeness Bay just southeast of Golden Sands Slough. The creek is fed by wetlands, and the upland area is undeveloped. The lower portion of the stream channel has been straightened, and the mouth is controlled by a tide gate.

Prior to the implementation of the TMDL cleanup plan actions, seven irrigation ditches drained to inner Dungeness Bay west of Cline Spit (Figure 2). These ditches have since been fully or partially piped, and discharge to Dungeness Bay is restricted. Most of the ditches still convey stormwater from county roads but irrigation water is conveyed through buried pipelines that are capped on the ends, thus no longer discharge tailwater. Only one irrigation ditch located west toward the base of Dungeness Spit remains open. These road-side ditches will continue to act as stormwater conveyance and may be used for occasional irrigation discharge under the control of the Cline Irrigation District to flush out the pipelines (Dougherty, 2008).

Three irrigation tailwater discharges to Matriotti Creek and two to Mudd Creek were eliminated shortly after the initial TMDL fecal coliform data collection. One other tailwater ditch to Lotzgesell Creek was eliminated in 2008. All six of these tailwater ditches were piped mainly due to the high levels of fecal coliform they delivered to the streams (Dougherty, 2008).

Additional study sites

Cassalery Creek is approximately 4.2 miles long and discharges to Dungeness Bay southeast of Cooper Creek. The creek was not included in the initial TMDL study. However, in 2008, the Washington State Department of Health (DOH) sampled the creek for fecal coliform as part of a shoreline survey. The survey found elevated levels of fecal coliform in the creek (WDOH, 2008c). Cassalery Creek is included in this study to identify the critical period showing exceedances of the water quality standards. Fecal coliform data collected during this project will be used to estimate the creek’s pollutant contribution to the marine environment.

Two additional sites that were sampled during the initial TMDL will again be sampled for fecal coliform during the study. These sites, MAT1.9 and MAT3.2 (Figure 2), do not have fecal coliform targets in the final TMDL. However, data collected from these sites will help to determine where cleanup activities have been effective.

Impairment and Historical Data Review

Initial impairment determination

Fecal coliform data collected by Clallam County from Matriotti Creek in 1991 showed exceedances of the water quality fecal coliform criteria. In 1996, Matriotti Creek, a tributary to Dungeness River, was placed on Washington State's 303(d) list of impaired waters due to violations of the fecal coliform water quality criteria (Ecology, 2008).

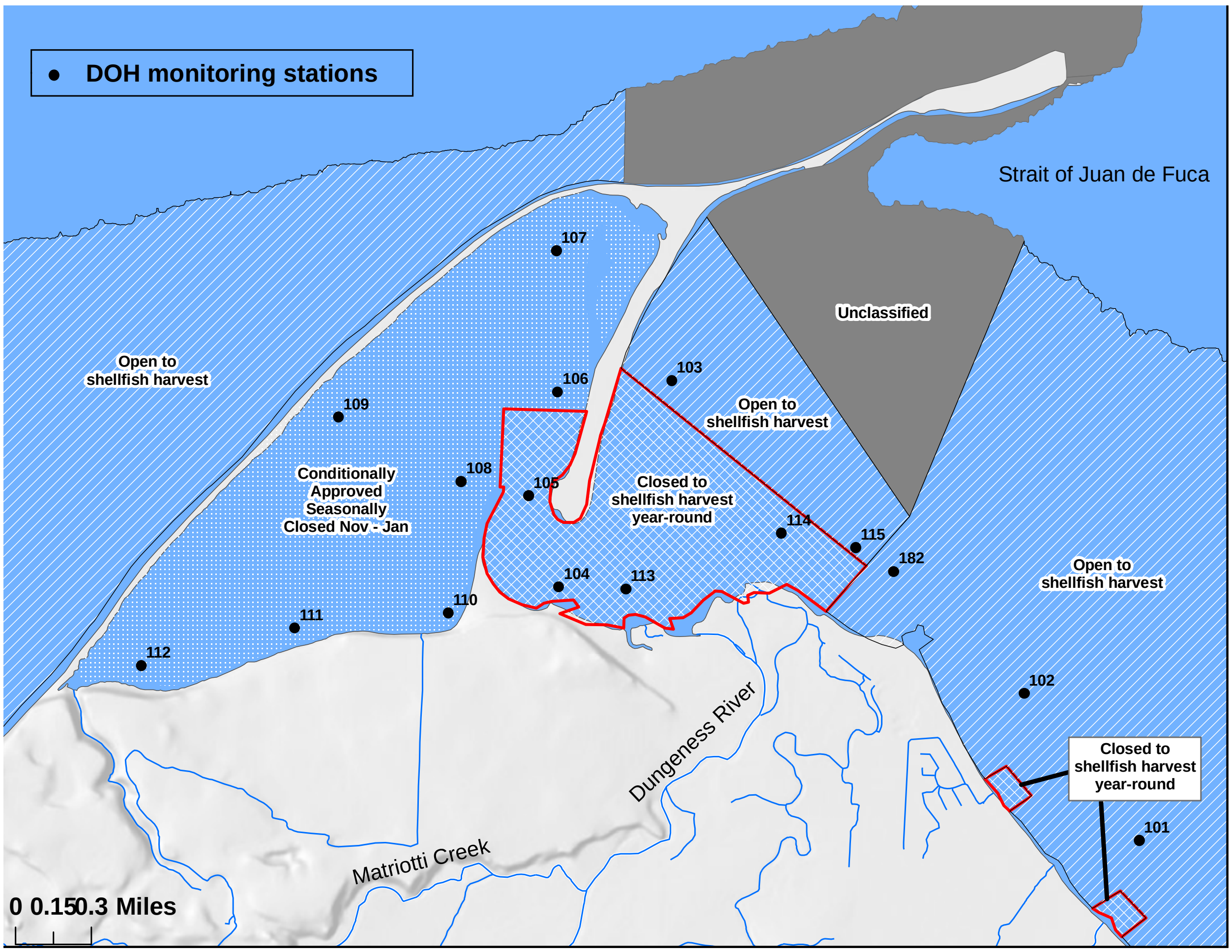

Figure 3. The Washington State Department of Health shellfish monitoring sites and shellfish growing areas in greater Dungeness Bay.

In 1997, DOH reported increasing levels of fecal coliform bacteria in Dungeness Bay near the mouth of the Dungeness River (WDOH, 1998). Bacteria levels continued to increase in later monitoring activities with higher levels of bacteria occurring in inner Dungeness Bay. As a result, DOH closed 300 acres in 2000 near the mouth of the Dungeness River to shellfish harvest: sites 104, 105, and 113 (Figure 3). In 2001, 100 more acres were added to the closure area in the vicinity of site 108. In 2003, DOH changed the classification of inner Dungeness Bay to "conditionally approved" for shellfish harvest from February through October with closure during November through January (Sargeant, 2004a). The three sites near the mouth remain closed to shellfish harvest year round, and an additional site (114) was added to the year-round closure.

Total Maximum Daily Load studies

The *Dungeness River and Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study* (Sargeant, 2002) sampling in the freshwater tributaries to the Bay occurred from 1999-2000. The purpose of the study was to determine the freshwater sources contributing high fecal coliform levels to the Bay. Elevated fecal coliform levels were found in several freshwater tributaries flowing into the Bay (Sargeant, 2002). The study area included the lower Dungeness River, Hurd Creek, Matriotti Creek, Meadowbrook Creek, and Meadowbrook Slough. The results of the study set target reductions for fecal coliform concentrations in these and other tributaries to the Bay.

Rensel Associates conducted bacteria sampling in Dungeness Bay and ditches discharging into Dungeness Bay from October 2001 to 2002. A circulation and bathymetry study was also conducted and resulted in a final technical report in April 2003 (Rensel, 2003). The Rensel study was summarized and used as the basis for the *Dungeness Bay Fecal Coliform Bacteria Total Maximum Daily Load Study* (Sargeant, 2004a). The TMDL addressed fecal coliform bacteria in inner and outer Dungeness Bay, irrigation ditches to the inner Dungeness Bay, and the Dungeness River. The study found that the critical period for inner Dungeness Bay is November through February and the critical period for the outer Dungeness Bay near the mouth of Dungeness River is March through July. Target reductions for fecal coliform concentrations were set for the Dungeness River and irrigation ditches discharging to inner Dungeness Bay.

The targets and reductions set in both the *Dungeness River and Matriotti Creek TMDL* study and the *Dungeness Bay TMDL* study (Table 3) are the basis of this effectiveness monitoring project.

Post-TMDL data collection and analysis

DOH monitors 13 marine sampling sites in the inner and outer Dungeness Bay (Figure 3). A recent analysis of DOH fecal coliform data from 2003-2007 shows a reduction in fecal coliform pollution. This trend in pollutant reduction was shown in 12 of 13 sites in the Dungeness shellfish growing area. Site 111 was the only site that did not show a significant reduction in fecal coliform concentration. No significant trend in fecal coliform concentration was found at site 111 (WDOH, 2008a). Although the general trend indicates a significant decline in marine fecal coliform concentrations since 2005, exceedances of the water quality standard for *10% not to exceed criteria* still occur at some sites.

At the request of the JSKT, DOH reclassified 725 acres of previously unclassified intertidal for commercial shellfish harvest. The reclassified Jamestown growing area is located southeast of the Dungeness River estuary along the shoreline and includes the DOH sampling sites: 183, 102, and 101 (see Figure 3). In December 2008, DOH approved this area for commercial shellfish harvest with the exception of two areas near the mouths of Golden Sands Slough and Cassalery

Creek (WDOH, 2008d). DOH shoreline surveys conducted in 2007 and 2008 found elevated fecal coliform levels in both waterbodies. Further evaluation in Golden Sands Slough found problems with on-site septic system and direct-sewage discharge to the slough. As a result, DOH prohibited commercial shellfish harvest at a 140-meter radius and 121-meter radius around the mouths of Golden Sands Slough and Cassalery Creek, respectively.

Clallam County and the JSKT continued fecal coliform sampling at many of the freshwater TMDL target sites from 2001 to 2004. These data, and data collected by Ecology's ambient monitoring program, were compared to the initial TMDL fecal coliform data collected in 1999 and 2000. The results of this analysis were presented in the *Dungeness River and Matriotti Creek Post-Total Maximum Daily Load Data Review* (Sargeant, 2004b).

The purpose of this 2004 report was to determine whether fecal coliform bacteria levels were improving and if the cleanup actions implemented had been effective. The analysis found significant improvement in some areas and seasons. The 2001- 2004 data showed that further reductions are necessary even though the trend during certain critical seasons was showing a decrease in fecal coliform concentrations. The Matriotti Creek sites showed the greatest decline and influenced a decline in fecal coliform concentrations found in the Dungeness River. Meadowbrook Creek showed a slight increase in fecal coliform concentrations (Sargeant, 2004a).

Further fecal coliform data collection in the Dungeness River watershed

Clallam County received a Centennial Clean Water Fund grant from Ecology in 2005. The JSKT received an EPA Targeted Watershed Grant (TWG) in 2005. Portions of both grant funds were allotted to perform fecal coliform monitoring in the Dungeness watershed (Streeter, 2005). Clallam County and the JSKT combined sampling efforts to monitor 58 sites in the Dungeness watershed for fecal coliform. Twenty-two of these sites were sampled monthly from September 2005 to August 2008. Among these sites, 7 of 12 TMDL target sites were included in the monitoring plan. Irrigation ditches included in the *Dungeness Bay TMDL* study were also sampled when water was flowing at the site (DeLorm, 2008). Monthly sampling data available from the seven TMDL target sites will be analyzed and included in the final effectiveness monitoring report. These data will be used to determine the trend of fecal coliform pollution prior to the effectiveness monitoring study.

DOH continues to conduct monthly sampling in Dungeness Bay to monitor fecal pollution in shellfish growing areas as part of the National Shellfish Sanitation Program (WDOH, 2008b). Thirteen DOH sites in the inner and outer Dungeness Bay area are sampled monthly (Figure 3). Data from this continuous monitoring program will be assessed to determine whether marine surface water quality standards are being met annually and during wet and dry seasons. DOH monitoring data will also be used to determine the fecal coliform concentration trends since the *Dungeness Bay TMDL* study.

DOH performed a shoreline survey of the Jamestown shellfish growing area which is located southeast along the shore from the Dungeness Bay growing area (WDOH, 2008d). The Jamestown shellfish growing area includes three DOH sampling sites and is currently unclassified (Figure 3). DOH sampled four tributaries for fecal coliform as part of this survey, including three TMDL target sites: Meadowbrook Creek, Golden Sands Slough, and Cooper Creek. Cassalery Creek was also sampled during this survey. Results showed at least one exceedance of the fecal coliform 10% criterion for all four sites.

Fecal coliform data collected in the Dungeness watershed can be found in Ecology's Environmental Information Management (EIM) system. Table 1 includes all Dungeness watershed fecal coliform data found in EIM, including the studies discussed in this plan.

Table 1. Dungeness River watershed fecal coliform data in EIM.

Study Name	User Study ID
SHS Blue Sky	CCWR_024
Clallam Water Quality Implementation Project	G9800086
Clallam Water Quality Implementation Project	CCWR_004
Shellfish Downgrade Response Dungeness Bay Project	G9900190
Dungeness/Matriotti Creek TMDL	DSAR0003
Clallam County State of the Waters	G0000179
Dungeness Irrigation Water Quality Improvement	G0100135
Dungeness Watershed Farm Plan Implementation	G0200260
Clean Water District Water Quality Monitoring and TMDL Implementation	G0300015
Clallam County-Wide Monitoring	G0500025
Statewide River and Stream Ambient Monitoring-WY2000 to present	AMS001
Statewide River and Stream Ambient Monitoring-WY1989 through WY1999	AMS001D

EIM does not maintain Department of Health data. Refer to the DOH annual reports (WDOH, 2007).
SHS: Sequim High School
TMDL: Total Maximum Daily Load
WY: Water year

TMDL Overview

Dungeness Bay and lower Dungeness watershed studies

TMDL studies were conducted for both the Dungeness watershed (Sargeant, 2002) and Dungeness Bay (Sargeant, 2004b). The main study objective for both studies was to recommend sufficient targets and load reductions for fecal coliform. This was done by estimating pollution loads and concentrations for tributaries to the Bay, modeling an acceptable loading capacity, and recommending load allocations.

The load reductions needed in upstream tributaries to meet the marine standard at the Dungeness River are more stringent than the water quality standards in the following waterbodies: Dungeness River (mouth to RM 0.3), Matriotti Creek, Hurd Creek, Meadowbrook Creek, Meadowbrook Slough, Golden Sands Slough, and Copper Creek. Fecal coliform loading from nonpoint sources were identified. There are no point-source permitted discharges in the study area. The TMDL studies attributed fecal coliform pollution to these nonpoint sources:

- On-site septic systems
- Pet and livestock waste
- Stormwater
- Wildlife

Cleanup and Implementation Plan

Dungeness Bay and lower Dungeness watershed cleanup implementation

Ecology prepared two reports: (1) the *Water Cleanup Plan for Bacteria in the Lower Dungeness Watershed Total Maximum Daily Load (TMDL) Submittal Report* (Hempleman and Sargeant, 2002) and (2) the *Water Cleanup plan for Bacteria in Dungeness Bay TMDL Submittal Report* (Hempleman and Sargeant, 2004). These reports outlined implementation strategies and cleanup actions needed to meet fecal coliform targets and load reductions described in the Dungeness TMDL studies. The reports also outline further research and monitoring to assist the adaptive management of cleanup actions. Both reports were submitted to EPA and approved.

The Dungeness Clean Water Workgroup is comprised of citizens and agency representatives who are involved in water quality issues in the area. Ecology staff worked with this organization to develop: (1) the *Clean Water Strategy for Addressing Bacteria Pollution in Dungeness Bay and Watershed and (2) the Water Cleanup Implementation Plan* (Streeter and Hempleman, 2004). These documents summarized the information provided in the TMDL submittal reports. The implementation plan also described activities recommended to help reduce bacteria levels, the responsibility and authority of the public entities, funding sources and needs, and a proposed cleanup schedule.

The Dungeness Clean Water Workgroup meets quarterly and continues to monitor the progress of cleanup activities in the watershed. The workgroup periodically reviews the status of past, ongoing, and planned implementation projects in the Dungeness watershed.

Study Objectives

This TMDL effectiveness monitoring study has three goals:

- To gather support for the fecal coliform bacteria TMDL implementation actions.
- To measure dissolved oxygen concentrations in some area streams.
- To support systematic review and improvement of water quality.

This study has three objectives to determine:

- If fecal coliform annual and seasonal targets set by the 2002 and 2004 TMDL studies and described in the 2004 Detailed Implementation Plan have been met.
- The trend of fecal coliform loading at two sites on Matriotti Creek.

- The dissolved oxygen conditions of selected waterbodies listed on the 2008 Section 303(d) list of impaired waterbodies.

Monitoring of fecal coliform bacteria is needed to assess how the conditions in Dungeness Bay and contributing freshwater sources to the Bay match the temporal and spatial goals set by the TMDL studies. In addition to data collected as part of this effectiveness monitoring sampling effort, we will include fecal coliform data from TMDL target sites collected monthly by Clallam County and the JSKT. We will also include the data collected monthly by the DOH in accordance with the United States National Shellfish Sanitation Program (USFDA, 2005). Final results will be reported in a technical memo and also in a final report including a table displaying geometric mean values (GMV), the 90th percentile values for each site, and a statistical analysis of the trend of water quality. The trend analysis will be performed using data collected since the original TMDL studies and data collected as part of the effectiveness monitoring effort.

These statistics will be generated on an annual and seasonal basis. The critical period for inner Dungeness Bay is the wet season (November through February). The critical period for the outer Dungeness Bay area, near the mouth of the Dungeness River is the irrigation season from March through October (Sargeant, 2004a). The effectiveness monitoring project design includes a sampling effort to support the evaluation of these two critical periods. Only data from sites within the Dungeness Bay and watershed effectiveness monitoring study area that meet all quality control requirements will be used in this evaluation.

A sampling and analysis goal of 100% completeness is set for this project. However, there are many reasons for missing sampling activities in a monitoring program. These include: (1) inclement weather or flooding, (2) hazardous driving or monitoring conditions, and (3) illness or unavailability of monitoring staff. Routinely missed sampling events could impart bias in expressions generated from final data. Sampling events will be rescheduled, when missed, in order to maintain integrity of the characterization effort. Field monitoring data loss due to equipment failure may occur; backup equipment will be available to minimize this problem. Apart from weather, unforeseen occurrences are random relative to water quality conditions. These occurrences will not affect long-term data analyses, except for effects from potential reduction in sample size.

Sampling Sites

Sites for TMDL Effectiveness Monitoring

The *Dungeness River and Matriotti Creek TMDL* study (Sargeant, 2002) and the *Dungeness Bay TMDL* study (Sargeant, 2004a) set target fecal coliform concentrations to reduce pollution in the Bay. The Detailed Implementation Plan describes these fecal coliform target limits for 11 sites in the Dungeness River watershed. A total of 13 sampling sites are included in this sampling plan (Table 2 and Figure 2). The target concentrations for these sites are listed in Table 3.

Site selection

Ten of the 11 target fecal coliform sites included in the Detailed Implementation Plan will be sampled during this study. One site, an irrigation tailwater return to Matriotti Creek (UPWARDIT), has been piped and capped (Holtrop, 2008). This waterbody no longer discharges to Matriotti Creek, and the contributing fecal coliform load is now zero. This site will not be sampled during the study.

Matriotti Creek showed a statistically significant improving trend in fecal coliform pollution from November 1999 to May 2004 (Sargeant, 2004a). Fecal coliform sampling conducted by the JSKT and Clallam County since 2004 still show some exceedances of the 90^{th} percentile at the TMDL target site (DeLorm, 2008). This study will conduct sampling at this site to determine current conditions. Additionally, two upstream sites included in the initial TMDL analysis (MAT1.9 and MAT3.2) will be sampled. The evaluation of these data will be performed by comparing seasonal and annual average fecal coliform load differences since the 1999-2000 TMDL study.

Cassalery Creek is located within the lower Dungeness Bay sub-watershed, which is the area of study for this TMDL effectiveness monitoring plan. This creek was not included in the initial TMDL study; however, recent stream data have shown elevated fecal coliform concentrations (WDOH, 2008a). A sampling site along Cassalery Creek (Figure 2) will be included in this study to determine pollutant contributions to the marine environment.

Additional Sites for Water Quality Criteria Monitoring

This study will also monitor dissolved oxygen concentrations at three sites in the lower Dungeness sub-watershed: Cassalery Creek, Cooper Creek, and Meadowbrook Creek (Figure 2 and Table 2). These sites were listed as impaired for dissolved oxygen according to Ecology's 2008 Water Quality Assessment (Ecology, 2008). Samples will be collected to evaluate current dissolved oxygen concentrations relative to Washington State's surface water quality criteria. *Extraordinary Aquatic Life* criteria (WAC 173-201A-200) apply to these waters. The criteria requires that "concentrations of dissolved oxygen are not to fall below 9.5 mg/L at a probability frequency of more than once every ten years on average."

Table 2. Monitoring sites.

Site ID	Description	Type	Latitude, Longitude (NAD83)
MC0.2	Meadowbrook Creek RM 0.2	TMDL	48.1520, -123.1233
COOP0.1	Mouth of Cooper Creek	TMDL	48.1377, -123.1012
GOLDSAND	Mouth of Golden Sands Slough	TMDL	48.1415, -123.1071
DR0.1	Dungeness River RM 0.1	TMDL	48.1479, -123.1267
DR0.8	Dungeness River RM 0.8	TMDL	48.1436, -123.1291
DR3.2	Dungeness River RM 3.2	TMDL	48.1162, -123.1494
MAT0.1	Mouth of Matriotti Creek	TMDL	48.1361, -123.1425
MAT1.9	Matriotti Creek at Cays Road	TMDL	48.1242, -123.1669
MAT3.2	Matriotti Creek at Schott Road	TMDL	48.1088, -123.1727
HC 0.2	Mouth of Hurd Creek	TMDL	48.1190, -123.1439
B DITCH 2 (Irrigation Ditch1)	Bluff Ditch 1 on Marine View Drive	TMDL	48.1497, -123.1559
THORNDIT (Irrigation Ditch2)	Bluff Ditch 2 on Marine View Drive	TMDL	48.1499, -123.1616
CASSALERY CR	Cassalery Creek at Jamestown Road	Added	48.1270, -123.1007

NAD – North American Datum

Table 3. Fecal coliform targets for each site.

Site ID	Geometric Mean (cfu/100 mL)	10% of Samples Cannot be Over (cfu/100 mL)
MC0.2	14	100
COOP0.1	35	100
GOLDSAND	19	100
DR0.1	13	42
DR0.8	9	43
DR3.2	6	28
MAT0.1	60	170
MAT1.9	60*	170*
MAT3.2	60*	170*
HC 0.2	12	100
B DITCH 2 (Irrigation Ditch 1)	50	100
THORNDIT (Irrigation Ditch 2)	50	100
CASSALERY CR	50	100

*Target values are based on MAT0.1 target. Analysis will compare annual and seasonal loads calculated by Sargeant (2002).

Logistical Considerations

A reconnaissance survey was conducted on October 9, 2008, to verify accessibility of sampling sites. A Global Positioning System (GPS) receiver verified site coordinates.

All sampling sites are near each other, and are located at bridge crossings or adjacent roadways. Permissions from land owners are required for some sites and have been obtained prior to sampling.

Manchester Environmental Laboratory (MEL) will be notified two weeks in advance of sample pickup dates. No logistical problems are anticipated.

Organization

Ecology employees involved in this project are listed in Table 4. All persons listed on the signature approval page are responsible for reviewing and approving the final Quality Assurance Project Plan.

Table 4. Organization of project staff and responsibilities.

Name/unit/section/ regional office/phone	Title	Responsibilities
Chad Brown SCS, EAP (360) 407-7026	Project Manager, Principal Investigator, and QAPP Author	Writes the QAPP. Collects samples and records field information. Conducts QA review of data, analyzes and interprets data, prepares data for upload to EIM, and writes the draft report and final report.
Mark Von Prause Directed Studies Unit, WOS, EAP (360) 407-7406	EIM Data Engineer and Field Assistant	Uploads data into EIM. Collects samples and records field information.
Lydia Wagner Water Cleanup/ Technical Unit WQP-SWRO (360) 407-6329	EAP Client TMDL Coordinator	Clarifies scope of the project, provides internal review of the QAPP, and approves the final QAPP.
Betsy Dickes Water Cleanup/ Technical Unit WQP-SWRO (360) 407-6296	Regional Field Assistance	Reviews the QAPP. Collects samples and records field information.
Kim McKee Water Cleanup/ Technical Unit WQP-SWRO (360) 407-6407	Client's Supervisor	Approves the final QAPP.
Garin Schrieve WQP-SWRO (360) 407-6721	Client's Section Manager	Approves the final QAPP.
George Onwumere Directed Studies Unit, WOS, EAP (360) 407-6730	Unit Supervisor for Study Area	Reviews the QAPP and draft technical memo. Approves the final QAPP and project budget.
Bob Cusimano, WOS, EAP (360) 407-6596	Section Manager for Study Area	Approves the final QAPP and technical memo.
Will Kendra, SCS, EAP (360) 407-6698	Author's Section Manger	Approves the final QAPP.
Stuart Magoon Manchester Environmental Laboratory, EAP (360) 871-8801	Director	Approves the final QAPP.
William R. Kammin, EAP (360) 407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

SCS – Statewide Coordination Section
EAP – Environmental Assessment Program
QAPP – Quality Assurance Project Plan
WOS – Western Operations Section
EIM – Environmental Information Management system
WQP-SWRO – Water Quality Program - Southwest Regional Office

Schedule

Project Schedule

The project schedule is in Table 5.

Table 5. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	
Field work	Monthly: November 2008 - October 2009
Laboratory analyses completed	November 2009
Environmental Information System (EIM) system	
EIM data engineer	Mark Von Prause
EIM user study ID	CBRO0001
EIM study name	Dungeness Bay and Watershed Fecal Coliform TMDL Effectiveness Monitoring
Data due in EIM	December 2009
Final report	
Author lead	Chad Brown
Schedule	
Draft due to supervisor	February 2010
Draft due to client/peer reviewer	March 2010
Draft due to external reviewer	April 2010
Final report due on website	May 2010

Sampling Schedule

The tentative field sampling schedule is listed below. Some dates may change due to unanticipated circumstances.

- November 18, 2008
- December 2, 2008
- December 16, 2008
- January 13, 2009
- January 27, 2009
- February 10, 2009
- February 24, 2009
- March 17, 2009
- April 7, 2009
- April 28, 2009
- May 26, 2009
- June 9, 2009
- June 23, 2009
- July 21, 2009
- August 18, 2009
- September 1, 2009
- September 15, 2009
- October 13, 2009

Experimental Design

The intent of this 2008-2009 study is to collect fecal coliform data at a high enough frequency and long enough duration to: (1) obtain a reasonable level of confidence in the results and (2) meet the objectives of this project. To evaluate the effectiveness of cleanup strategies, staff will collect representative samples through the use of sites and targets identified by the TMDL technical studies (Sargeant, 2002; Sargeant, 2004b). Staff will also use the same methods and frequency of sampling as the TMDL study.

Eighteen sampling events will be performed periodically during November 2008 through October 2009. To ensure an adequate dataset to perform seasonal analysis, sampling events will occur approximately every two weeks during the wet season (November through February) and approximately every three weeks during the dry season (March through October). Many of the latter sampling dates were chosen to coincide with the lowest tides of the dry season. Low-tide sampling helps determine freshwater conditions in tidally-influenced sites by collecting samples when marine water is at its lowest.

Sampling locations include all compliance sites described in the Dungeness TMDL studies, except those irrigation ditches that no longer discharge into Dungeness Bay or tributaries to the bay. However, all ditches that have TMDL targets will be visited during each sampling event.

Supplemental membrane filtration (MF) samples will be collected if stormwater is flowing at these sites. Samples will only be collected from sites with measureable flow. Two sites, MAT1.9 and MAT3.2, will also be sampled for fecal coliform. These sites were sampled during the initial TMDL from 1999 to 2000 to develop the target at the MAT0.1 site. Flow data collected at sites MAT0.1 and MAT1.9 and staff gage readings at site MAT3.2 will allow comparison to past fecal coliform loading data. If further cleanup activities are necessary to meet the MAT0.1 target, these data will help focus future cleanup activities.

Water samples from freshwater TMDL target sites will be analyzed using a MF method. Water samples from the GOLDSAND TMDL target site will be analyzed using a most probable number (MPN) method. A 250-mL water sample will be collected at each site. In addition, field duplicate MF samples will be collected during each sampling event at specified sites (Tables 6a and 6b). Schedule field duplicate MPN samples will also be collected. These samples provide 20% or greater field duplication rate for both MF and MPN analyses.

Eighteen MF samples will be collected from 12 TMDL target sites. Eighteen MF samples will also be collected from the additional Cassalery Creek (CASSALERY CR) site. Eighteen MPN samples will be collected from the Golden Sands Slough (GOLDSAND) target site. This site is highly influenced by marine water. Sargeant (2002) analyzed samples from this site by MPN method for comparison with MPN data collected by the DOH in adjacent marine water. Samples collected during this study will be analyzed by MPN method. This method will allow for data comparison with the MPN target concentration determined at the GOLDSAND site by Sargeant (2002).

Table 6a. Allocation of fecal coliform samples at the TMDL target sites (November 2008 – April 2009).

Site ID	Nov. 18 2008	Dec. 2 2008	Dec. 16 2008	Jan. 13 2009	Jan. 27 2009	Feb. 10 2009	Feb. 24 2009	Mar. 17 2009	Apr. 7 2009
MC0.2	2	1	1	1	1	2	1	1	1
COOP0.1	1	2	1	2	1	1	2	1	1
GOLDSAND	1*	1*	2*	1*	2*	1*	1*	1*	1*
DR0.1	1	1	1	1	1	2	1	1	2
DR0.8	1	1	1	2	1	1	2	1	1
DR3.2	1	1	1	1	2	1	1	2	1
MAT0.1	2	1	1	1	1	2	1	1	2
MAT1.9	1	2	1	1	1	1	2	1	1
MAT3.2	1	1	2	1	1	1	1	2	1
CASSALERY CR	1	1	1	1	1	1	1	1	2
HC 0.2	1	1	1	2	1	1	1	1	1
B DITCH 2	1	1	1	1	1	1	1	1	1
THORNDIT	1	1	1	1	1	1	1	1	1
MF Total	14	14	13	15	13	15	15	14	15
MPN Total	1	1	2	1	2	1	1	1	1

* Indicates where a water 250-mL sample will be collected for analysis by Most Probable Number.
Shaded cells indicate a field replicate collection event.

Table 6b. Allocation of fecal coliform samples at the TMDL target sites (May – October 2009).

Site ID	Apr. 28 2009	May 26 2009	Jun. 9 2009	Jun. 23 2009	Jul. 21 2009	Aug. 18 2009	Sep. 1 2009	Sep. 15 2009	Oct. 13 2009
MC0.2	2	1	1	2	1	1	1	1	1
COOP0.1	1	2	1	1	2	1	1	1	1
GOLDSAND	1*	1*	2*	1*	1*	2*	1*	1*	1*
DR0.1	2	1	1	2	1	1	2	1	1
DR0.8	1	2	1	1	2	1	1	2	1
DR3.2	1	1	2	1	1	2	1	1	2
MAT0.1	2	1	1	2	1	1	2	1	1
MAT1.9	1	2	1	1	2	1	1	2	1
MAT3.2	1	1	2	1	1	2	1	1	2
CASSALERY CR	1	1	1	1	1	1	2	1	1
HC 0.2	1	1	1	1	1	1	1	2	1
B DITCH 2	1	1	1	1	1	1	1	1	1
THORNDIT	1	1	1	1	1	1	1	1	1
MF Total	15	15	14	15	15	14	15	15	14
MPN Total	1	1	2	1	1	2	1	1	1

* Indicates where a water 250-mL sample will be collected for analysis by MPN.
Shaded cells indicate a field replicate collection event.

Including field replicates, a total of 22 MPN samples and 260 MF samples are scheduled to be collected during this study. As shown by sampling conducted by Clallam County and the JSKT, flow is infrequent at the scheduled ditch sites and supplemental ditch sites. Fewer than the scheduled 260 MF samples are expected if B DITCH 2 and THORNDIT are not flowing during sampling events.

Three sites (MC0.2, COOP0.1, GOLDSAND) are tidally influenced. Conductivity measurements will be recorded at these sites to determine salinity concentration within the water column at the time of sampling.

Costs

Total project costs (laboratory plus travel) are approximately $7,988 ($6,926 +$1,062). The calculated cost assumes collection of samples at each site during each site visit. Flowing water is rarely expected at two sites; therefore, laboratory costs may be up to 14% less than projected.

Laboratory

These costs were calculated using MEL's price list for Fiscal Year (FY) 2009.

Fecal coliform by MPN: 22 samples @ $43/sample =	$ 946
Fecal coliform by MF: 260 samples @ $23/sample =	$5,980
Total laboratory costs (including pre-planning 50% discount)	$6,926

Travel

Approximately $1,062 will be required for *per diem* expenses. Lodging will not be needed, but length of field days might exceed 11 hours for each round-trip by staff from Ecology's Headquarter office in Lacey. These costs were developed using Ecology's rates ($59 *per diem*) for Clallam County travel, in effect since October 1, 2008.

Quality Objectives

Quality objectives are statements of the precision, bias, and lower reporting limits necessary to address project objectives. Precision and bias together express data accuracy. Other considerations of quality objectives include representativeness and completeness.

Precision is a measure of data consistency. It is expressed as the relative standard deviation (RSD) and derived from replicate sample analyses. It is subject to random error. RSD is determined by dividing the standard deviation of a sample by the mean for the same sample and then multiplying by 100%. For this project, each sample for which an RSD will be calculated will consist of paired duplicates.

Bias is a measure of the systematic error between an estimated value for a parameter and the true value. Systemic errors can occur through poor technique in sampling, sample handling, or analysis. Bias from the true value is very difficult to determine for this set of parameters. We will minimize the bias through strict adherence to standard operating procedures (SOPs) (Ecology, 1993). Field staff will follow the SOPs listed in this plan (Swanson, 2007; Mathieu, 2006a; Mathieu, 2007; Gallagher and Stevenson, 1999). Care will also be taken to prevent contamination, a frequent problem with bacteria sampling. Field dissolved oxygen and conductivity meters will be calibrated before each day of sampling and checked following each day of sampling using a standard solution of known conductivity. There will be back-up equipment during sampling events in case of equipment failure.

Measurement quality objectives will vary for parameters based on their measurability in the natural environment. Increasing the number of replicates will improve precision estimation and confidence in decision making. For example, staff plans a 20% duplicate sampling rate (Tables 6a and 6b) for fecal coliform sampling because this parameter has inherently large variability.

The sampling plan seeks to collect *representative* samples through the use of sites and targets identified by the TMDL technical studies (Sargeant, 2002; Sargeant, 2004b). Staff will also use the same methods and frequency of sampling as the TMDL study. Furthermore, this study will span a year in duration, as did the 1999 to 2000 TMDL study.

Representativeness generally for the project will be assured through the use of standardized protocols. Staff will determine where samples represent freshwaters by measuring conductivity. Sampling events with mean conductivity results of greater or less than 17,000 µS/cm @ 25° C will be determined to be marine or freshwater fecal coliform samples, respectively.

The objective for sampling *completeness* is 100% successful data collection. Completeness will be assessed by examining the: (1) number of samples collected compared to the sampling plan, (2) number of samples shipped and received at MEL in good condition, (3) laboratory's ability to produce usable results for each sampling event, and (4) sample results accepted by the project manager.

Table 7 lists the measurement quality objectives (MQOs) for this project.

Table 7. Measurement quality objectives.

Analysis	Equipment Type and Method	Duplicate Samples Relative Standard Deviation (RSD)	Method Reporting Limits and/or Resolution
Field Measurements			
Discharge[1]	Marsh McBirney Flow-Mate Flowmeter	+/- 0.1 ft/s	0 cfs[2]
Dissolved Oxygen	Azide-modified Winkler titration	10% RSD	0.1 mg/L
Dissolved Oxygen	Hydrolab MiniSonde®	10% RSD	0.1 mg/L
Water Temperature[1]	Hydrolab MiniSonde®	+/- 0.1° C	0.01° C
Specific Conductivity[3]	Hydrolab MiniSonde®	+/- 0.5%	0.1 µS/cm 0.2 @ 25° C
pH[1]	Hydrolab MiniSonde®	0.05 SU	1 to 14 SU
Laboratory Analyses			
Fecal Coliform MF[4]	SM 9222 D	50% of replicate pairs < 20% RSD 90% of replicate pairs <50% RSD[5]	1 cfu/100 mL
Fecal Coliform MPN[6]	SM 9221 E2	50% of replicate pairs < 20% RSD 90% of replicate pairs <50% RSD[5]	1 cfu/100 mL

[1] Expressed in units of measurement, not percentages.
[2] Velocity range of Marsh-McBirney Flo-Mate Model 2000 is -0.5 to 19.99 ft/s: www.marsh-mcbirney.net/manuals/Model_2000_Manual.pdf.
[3] Expressed as a percentage of reading, not RSD.
[4] Analyzed by *Membrane Filter* method (APHA, AWWA, and WEF, 1998).
[5] Replicate results with a mean of less than or equal to 20 cfu/100 mL will be evaluated separately in accordance with Mathieu (2006b).
[6] Analyzed by *Most Probable Number* method (APHA, AWWA, and WEF, 1998).

Field Procedures

Safety

Staff should adhere to the Environmental Assessment Program's Safety Manual (EAP, 2006). Field operations will be discontinued any time personnel determine that driving conditions, site access, or sampling conditions are unsafe for that site.

Sampling

Fecal coliform sampling will be performed according to Ecology's Environmental Assessment Program standard operating procedures (SOPs). The *Standard Operating Procedure for Sampling Bacteria in Water, Version 1.0* (Mathieu, 2006a) will be used.

Bacteria grab samples will be collected directly into pre-cleaned containers supplied by the laboratory and described in MEL (2008). These will be 250-mL bottles for both MF and MPN samples. Samples will be collected from the stream center of flow thalweg whenever possible. Samples will be labeled, transferred to a cooler, placed in crushed or cube ice, and kept at between 0°C and 6°C. All samples will be delivered to Manchester Environmental Laboratory (MEL) no later than 20 hours after collection. Analysis will be performed within 24 hours of collection.

Following each field sampling event, field staff will prepare samples and store in the cooler at Ecology's operations center. Field staff will use chain-of-custody records, as described in the Lab Users Manual (MEL, 2008). These include field log books and the Laboratory Analyses Required form. MEL staff will transport samples to MEL to meet the 24-hour holding time requirement

Measurements

Flow

Instantaneous discharge measurements will be recorded during each sampling run at the Cassalery Creek site and Matriotti Creek sites, MAT0.1 and MAT1.9. These measurements will be collected according to field methods described by the American Fisheries Society (Gallagher and Stevenson, 1999) and according to methods in the meter manufacturer's operating manual. Duplicate discharge measures will be recorded during each month of the project at select sites to meet measurement quality objectives.

Conductivity (or salinity)

Field conductivity measurements will be recorded from three sampling sites: Golden Sands Slough, Cooper Creek, and Cassalery Creek. Measurements will be collected using a Hydrolab

MiniSonde®. Two equidistant measurements will be recorded from the water column (lower and upper water column). When the depth at a site is greater than four feet, three equidistant measurements will be recorded. The mean conductivity value at each site will be used to determine if freshwater or marine conditions apply according to state water quality standards (Ecology, 2006).

Conductivity units (µS/cm at 25° C) can be converted to salinity units (ppt) based on *Standard Methods* (APHA, AWWA, and WEF, 1998). This conversion is available online (www.fivecreeks.org/monitor/sal.html). Field conductivity measurements will be collected at each sampling site using a Hydrolab MiniSonde®. Measurements will be collected according to field methods described in the *Standard Operations for Hydrolab® DataSonde® and MiniSonde® Multiprobes* (Swanson, 2007).

Dissolved oxygen

Field dissolved oxygen measurements will be collected at each sampling site using a Hydrolab MiniSonde®. Measurements will be collected according to field methods described in the *Standard Operations for Hydrolab® DataSonde® and MiniSonde® Multiprobes* (Swanson, 2007). Selected sites will be sampled and analyzed for dissolved oxygen concentrations using the azide-modified Winkler method (Mathieu, 2007). These data will be used to correct concurrent probe measurements for each sampling run. Multi-probe, pre- and post-calibration procedures (Swanson, 2007) will also be performed.

pH

Field pH measurements will be collected at each sampling site using a Hydrolab MiniSonde®. Measurements will be collected according to field methods described in the *Standard Operations for Hydrolab® DataSonde® and MiniSonde® Multiprobes* (Swanson, 2007). Multi-probe, pre-and post-calibration procedures (Swanson, 2007) will be performed for each sampling run.

Laboratory Measurement Procedures

Laboratory analyses will be performed in accordance with the *Manchester Environmental Laboratory Users Manual* (MEL, 2008). This manual indicates that the reporting limits listed in Table 7 can be achieved by using analytical methods listed in Table 8. The laboratory staff will consult the project manager if there are any changes in procedures over the course of the 2008-2009 project timeline, or if other difficulties arise.

The field crew will communicate with the laboratory to ensure that laboratory resources are available. The project team will follow normal Manchester Environmental Laboratory procedures for sample notification and scheduling. With adequate communication, sample quantities and processing procedures should not overwhelm the laboratory capacity. When laboratory-sample load capacities are heavy, rescheduling of individual surveys may be necessary.

Table 8. Summary of laboratory analysis procedures for fecal coliform bacteria.

Method	Estimated Range (cfu/100 mL)	Detection Limit (cfu/100 mL)	Holding Time[3]	Preservation	Container[4]
MF[1]	< 1 to > 5000	1	24 hrs	Chill (4 °C)	250 mL glass or poly autoclaved
MPN[2]	< 1 to > 5000	1	24 hrs	Chill (4 °C)	250 mL glass or poly autoclaved

[1] *Membrane Filter* method (APHA, AWWA, and WEF, 1998).
[2] *Most Probable Number* method (APHA, AWWA, and WEF, 1998).
[3] Holding time as required by Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, and WEF, 1998).

Quality Control Procedures

Total variation for field sampling and analytical variation will be assessed by collecting replicate samples. Bacteria samples tend to have a high relative standard deviation (RSD) between replicates compared to other water quality analyses. Bacteria sample precision will be assessed by collecting replicates for 20% or more of samples during the study. The percent of replicate samples collected during each survey will vary (see Tables 6a and 6b). Manchester Environmental Laboratory (MEL) routinely duplicates sample analyses in the laboratory to determine the presence of bias in analytical methods. The difference between field variability and laboratory variability is an estimate of the sample field variability.

Laboratory

All samples will be analyzed at MEL following standard quality control (QC) procedures outlined in the Laboratory Quality Assurance Plan and the Laboratory User Manual (MEL, 2007 and 2008). The laboratory's data quality objectives are documented in MEL (2007). QC procedures used during field sampling and laboratory analysis will provide estimates toward understanding accuracy of the monitoring data. If any of these QC procedures are not met, the associated results will be qualified and used with caution, or not used at all.

MEL has a maximum holding time for microbiological samples of 24 hours (MEL, 2008). MEL accepts samples Monday through Friday; therefore, sampling events can occur Sunday through Thursday. Sampling event planning has been structured to ensure that sample holding times will not be exceeded.

The results of the laboratory QC sample analyses should be used in determining compliance with measurement quality objectives (Table 7). Variation will be described for field and laboratory results by examining replicate samples and comparing to measurement quality objectives. Laboratory QC data for fecal coliform duplicates will be compared to the measurement quality objectives for precision.

Field

Flow meters used in measuring stream discharge will be checked and calibrated at the start of each sampling day and will follow manufacturers procedures. Duplicate discharge measurements will be used to describe the variability. Both the initial value and the duplicate value will be reported, regardless of the magnitude in RSD (consistent with Butkus, 2005).

QC of field conductivity, dissolved oxygen, and pH measurements will be performed according to methods of Swanson (2007). The meter will be calibrated daily prior to use. Daily measurements will be checked by measuring a solution of known conductivity following field sampling activities.

Selected sites will be sampled and analyzed for dissolved oxygen concentrations using the azide-modified Winkler method (Mathieu, 2007). These data will be used to correct concurrent dissolved oxygen probe measurements for each sampling run.

Data Management Procedures

Laboratory Data

Procedures for laboratory data reduction, review, and reporting are outlined in the Manchester Environmental Laboratory Users Manual (MEL, 2008). Laboratory staff will be responsible for the following functions:

- Fecal coliform data verification.
- Proper transfer of fecal coliform data to the Laboratory Information Management System (LIMS).
- Reporting data to the project manager.

The Environmental Information Management (EIM) data engineer will subsequently enter data into Ecology's EIM system. The project manager will perform the following functions:

- Review data for errors (quarterly) and make procedural adjustments as necessary.
- Apply corrective measures to minimize errors and validate the quality of the data.
- Review data site and results information in EIM when data entry is complete.

Major changes will require notification of those who have signed this Quality Assurance Project Plan. The project manager may approve data that do not meet measurement quality objectives (Table 7), but only after consultation with these signatories, and only with appropriate data qualification.

Laboratory Reports

Manchester Environmental Laboratory (MEL) will report all laboratory results to the project manager within 30 days of sample delivery. The reports will include narratives, numerical results, data qualifiers, and costs.

High fecal coliform bacteria densities (≥ 200 cfu/100 mL) will be reported to Ecology's Southwest Regional Office (SWRO) and the project manager in accordance with the Environmental Assessment Program's official Bacteria Notification Policy (1-03). All other data will be made available to the SWRO for release after quality control and EIM entry are completed.

Field Data

Field observations and measurement data will be recorded by pencil onto a notebook with waterproof pages. The project manager will review the field data after each sampling run and calculate discharge from water velocity measurements. The project manager will review calculated data for errors and make procedural adjustments as necessary. All field data will then be entered into Excel® spreadsheets (Microsoft, 2001) for later integration with laboratory data before exporting to Ecology's EIM database. Data entry and validation will be performed by staff within Ecology's Environmental Assessment Program. All entered data will be validated by an internal, independent reviewer. Errors found will be identified, flagged, and corrected by the project manager. The EIM data engineer will upload all data into the EIM database.

Final Study Report

A technical memo and final study report will compare observed fecal coliform bacteria geometric mean values (GMVs) and 90th percentiles to target concentrations. Current fecal coliform levels will be reported to better characterize current water quality conditions in the watershed.

Estimation of univariate statistical parameters may be generated using Microsoft Excel® or other appropriate computer software. These parameters may include arithmetic mean, geometric mean, median, standard deviation, range of data by site and sampling survey, and graphical presentation of the data.

A non-parametric Seasonal Kendall Trend test will be used to determine statistically significant trends at each site. The statistical analysis program WQHYDRO (Aroner, 2003) will be used for these analyses.

The technical memo and study report will also synthesize data and information from other available sources. This will include analysis of routing monitoring data previously collected by the Jamestown S'Klallam Tribe and Clallam County.

Audits and Reports

Manchester Environmental Laboratory (MEL) will submit laboratory reports, quality assurance worksheets, and chain-of-custody records to the Environmental Assessment Program staff. Any problems and associated corrective actions will be reported by the laboratory to the project manager. The project manager is responsible for periodic audit updates to the team and client as well as for the final report.

Documentation from MEL should include any quality control results associated with the data in order to evaluate the accuracy of the data and to verify that the quality objectives are met.

Data Verification and Usability Assessment

Data Verification

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. Manchester Environmental Laboratory (MEL) is responsible for performing the following functions:

- Reviewing and reporting QC checks on instrument performance such as initial and continuing calibrations.
- Reviewing and reporting case narratives. This includes comparison of QC results with method acceptance criteria such as precision data, surrogate and spike recoveries, laboratory control sample analysis, and procedural blanks.
- Explaining flags or qualifiers assigned to sample results.
- Reviewing and assessing MEL's performance in meeting the conditions and requirements set forth in this sampling plan.
- Reporting the above information to the project manager or lead.

After measurement results have been recorded, the results are verified to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions.
- Results of QC samples accompany the sample results.
- Established criteria for QC results were met.
- Data qualifiers are properly assigned where necessary.
- Data specified in the Sampling Process Design were obtained.
- Methods and protocols specified in the Quality Assurance Project Plan were followed.

MEL is responsible for verifying all analytical results. Reports of results and case summaries provide adequate documentation of the verification process. MEL analytical data will be reviewed and verified by comparison with acceptance criteria according to the data review procedures outlined in the Lab Users Manual (MEL, 2008). Appropriate qualifiers will be used to label results that do not meet quality assurance requirements. An explanation for data qualifiers is provided.

Field results will also be verified by field staff before leaving the site after measurements are made. Detailed field notes will be kept to meet the requirements for documentation of field measurements. The field lead is responsible for checking that field data entries are complete and error free. The field lead should check for consistency within an expected range of values, verify measurements, ensure measurements are made within the acceptable instrumentation error limits, and record anomalous observations.

Data Usability Assessment

Data usability assessment follows verification. This involves a detailed examination of the data package using professional judgment to determine whether the method quality objectives (MQOs) have been met. The project manager examines the complete data package to determine compliance with procedures outlined in the Quality Assurance Project Plan and the SOPs. The project manager is also responsible for the data usability assessment by ensuring that the MQOs for precision, bias, and sensitivity are met.

Part of this process is an evaluation of precision. Precision will be assessed by calculating relative standard deviations (RSDs) for field and laboratory duplicates. Laboratory duplicates will yield estimates of precision performance at the laboratory only. Field duplicates will indicate overall variability (environmental + sampling + laboratory). Acceptable precision performance is outlined in the MQOs (Table 7).

Completeness will be assessed by examining: (1) the number of samples collected compared to the sampling plan, (2) the number of samples shipped and received at MEL in good condition, (3) MEL's ability to produce usable results for each sampling event, and (4) the sample results accepted by the project manager.

To analyze data for its usability, the project lead will consider precision, completeness, and documentation of adherence to protocols. Data will also be examined for extremes (for example, against historical records and against the distributions of these project data). Extreme values will require logical explanations. Staff expects to have variable fecal coliform data because the TMDL study found this parameter to be variable in the Dungeness River watershed. Identified sources of bias will be described in the final project report.

The data will be used to determine whether TMDL targets and freshwater quality criteria have been met. The project manager will make this determination by examining the data and all associated quality control information. This includes target geometric mean, 90^{th} percentile values, and required percent reductions.

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Appendix. Glossary, Acronyms, and Abbreviations

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Bathymetry: Measure of depth of a waterbody.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Load allocation (LA): The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a waterbody can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving waterbody.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than five acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or is likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Salmonid: Any fish that belong to the family Salmonidae. Basically, any species of salmon, trout, or char.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Thalweg: The deepest and fastest moving portion of a stream.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Wasteload allocation (WLA): The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

cfs	Cubic feet per second
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management System
FDA	U.S. Food and Drug Administration
GIS	Geographic Information System software
JSKT	Jamestown S'Klallam Tribe
LLID	Latitude/Longitude Identification System
MEL	Manchester Environmental Laboratory
MF	Membrane Filter
MPN	Most Probable Number
MQO	Measurement quality objectives
NPDES	National Pollution Discharge Elimination System
NSSP	National Shellfish Sanitation Program
SWRO	Southwest Regional Office
ppt	Parts per thousand
QA	Quality assurance
QC	Quality control
RM	River mile
TMDL	Total Maximum Daily Load (water cleanup plan)
WAC	Washington Administrative Code
WQA	Water Quality Assessment
WDFW	Washington Department of Fish and Wildlife